Center For Meteorite Studies
ASU
Arizona State University

ASU College of Liberal Arts & Sciences
Arizona State University

Newsletter

ISSUE NO. 6
SPRING 2009

Bringing the Moon to Arizona

As implied by its name, research at the Center for Meteorite Studies focuses in large part on meteorites, most of which originated on asteroids. However, the Center also supports research on other Solar System bodies such as the Sun, Moon and Mars. The practice of working on planetary samples other than meteorites was established in the early history of the Center when Founding Director Carleton Moore was among the handful of scientists in the world selected to analyze Moon samples returned by the Apollo missions.

The seeds of Moore's Apollo analyses were planted years before the Moon landings. As newly-appointed Director of CMS, Moore attended a conference of meteorite curators in England in 1962. There, metallurgist Howard Axon suggested that carbon contents of meteorites should be studied, as theoretical work on iron and steel carried out by metallurgists could benefit from carbon values from meteorites. Inspired by the suggestion, Moore obtained a state-of-the-art LECO carbon analyzer, which operated by combusting a sample and then analyzing the resulting products by gas chromatography. Moore and CMS Curator Charles Lewis began by analyzing carbon in iron meteorites and, once they successfully demonstrated the technique, they moved onto analyzing a wide variety of chondrite meteorites. The expertise developed with carbon enabled Moore, Lewis and the increasing numbers of undergraduate and graduate researchers in the CMS to move onto the characterization of other volatiles in meteorites including nitrogen and sulfur. Their work resulted in numerous publications and established the reputation of the CMS in studies of volatile elements in meteorites.

Prior to the first Moon landing, Moore's successful meteorite analyses helped earn him a grant from NASA to analyze carbon in the samples returned by the first lunar landing mission, Apollo 11. This work was independent of the Lunar Sample Preliminary Examination Team (LSPET), the team of scientists assigned to analyze the samples in the Lunar Receiving Laboratory (LRL) at the Manned Spacecraft Center (MSC; now known as Johnson Spaceflight Center) immediately upon return of the lunar samples to Earth. However, when carbon analyses of the Apollo 11 samples by the LSPET were unsuccessful, Robin Brett, a NASA geochemist in charge of science at the MSC, brought Moore onto the LSPET immediately to get the needed carbon data. Because the CMS was the only facility with the

CMS Curator Charles Lewis analyzes a meteorite in the CMS's LECO carbon analyzer

CMS Administrative News

Our Mission: The Arizona State University Center for Meteorite Studies, home to the world's largest university-based meteorite collection, creates new knowledge about the origin of our planetary system through the study of meteorites so that we may understand the pathway to forming habitable worlds. The Center is dedicated to sharing this knowledge with students, educators and the general public by providing educational opportunities that expand awareness and understanding of the science of meteoritics. In support of its research and education activities, the Center aggressively pursues cutting edge conservation approaches for its existing meteorite collection, while also seeking new, significant meteorite samples, so that they may be made accessible to the local and international public and science community for posterity.
Our Location: Bateman Physical Science Center C-wing, Room 139
ASU Tempe Campus
Our Hours: Mon-Fri 9am-5pm (closed on ASU holidays)
http://meteorites.asu.edu

Letter from the Director

Welcome to the Spring edition of our biannual Newsletter. With the recent renewed interest in lunar exploration, and as NASA prepares to launch the Lunar Reconnaissance Orbiter this summer, it is fitting that the feature article of this Newsletter delves into the fascinating story behind the first analyses of the Apollo Moon rocks conducted in the CMS under the leadership of then Director Carleton Moore. In addition, you will read about the progress we have made on a project funded by ASU's Women and Philanthropy organization, and about recent additions to our meteorite collection (including a meteorite found by our very own Collections Manager, Dr. Laurence Garvie!). We hope you will enjoy this "behind-the-scenes" peek into the latest collections and research activities in the Center for Meteorite Studies.

Meenakshi Wadhwa
Director

Bringing the Moon to Arizona (continued)

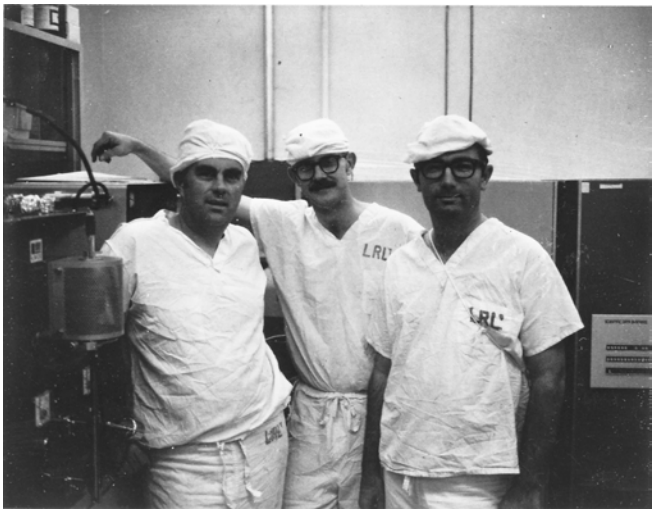
analytical machinery in place for proven carbon analyses, Moore flew to Houston to pick up the Apollo 11 samples and brought them back to ASU for analysis.

Moore (second from right) and graduate student Everett Gibson (far right) bring Apollo 11 samples to ASU with a little help from friends

On the evening of Tuesday, October 7, 1969, Moore, Lewis, a LECO salesperson (Mitch Schwartz), and a graduate student (Bob Kelly), crowded into the CMS lab to conduct the first carbon analysis of a lunar sample. The late start time was to ensure that they would not be interrupted by any of the usual daytime university business. The first sample analyzed was of the lunar regolith. Moore vividly remembers when the counter on the LECO analyzer began to register a reading. His overwhelming emotion was relief - there was carbon to be had in the lunar samples and they were analyzing it! Each person in attendance signed the analysis log book at 9:30 PM to commemorate the event. Analyzing samples with detectable carbon in them in their first effort built the group's confidence in their methods, but it was also fortuitous. Samples return by later missions, like the lunar highlands materials predominantly consisting of

Bringing the Moon to Arizona (continued)

anorthosite collected by Apollo 16, were nearly devoid of carbon. Such a null result early on might have proved confusing or disheartening.



Moore, Lewis and Gibson (left to right) pose in front of their analytical setup in the Lunar Receiving Laboratory in Houston

As the Apollo 11 analyses were underway at the CMS, the rapidly approaching launch of Apollo 12 compelled Moore to work quickly to recreate the analytical setup from the CMS at the LRL so that his future LSPET analyses could be done in Houston. The samples that the LSPET were charged with analyzing were chosen by the curatorial staff at the MSC after they cataloged the samples returned by each mission. When an important sample or suite of samples was identified, it was released to the LSPET members for analysis. The cataloging and release process could take months; thus, some LSPET members would stay in Houston until all the preliminary analyses were completed for a mission's samples. Rather than follow this model, Moore traveled to Houston for each sample release, leaving on a Friday night and returning on a Sunday night so as not to affect his Center directorship and teaching duties. After Apollo 14, the lunar samples were no longer deemed a potential biological hazard because the likelihood of lunar organics or life forms was eliminated by analyses of the Apollo 11, 12 and 14 samples. Moore and his team could then carry out the carbon analyses for LSPET on the Apollo 15, 16 and 17 samples at ASU.

Security around the lunar samples was understandably tight. The Apollo 15, 16 and 17 samples and other samples Moore was authorized to analyze through his own grants were mailed from the MSC but Moore had to pick them up directly from the post office. Once at ASU, the samples were kept in a cabinet secured with two locks from a single vendor designated by NASA. The lock did not come with a set combination. Moore was required to set the combination himself so that he would be the only one capable of opening the lock. NASA also required that the samples be checked by law enforcement personnel twice a day so that in the event the samples went missing, the time of disappearance would be tightly constrained. During late nights of work by Moore and his students, though, they often found that the nighttime sample check was not done. Fortunately, additional security for the cabinet was provided as only the Center could. Moore kept heavy iron meteorites in the base of the storage cabinet to ensure it could not be moved.

Moore and the CMS team ultimately analyzed over 200 lunar samples. These analyses, along with discussions with ASU Department of Geology colleague Jack Larimer as well as the data from other LSPET researchers, helped Moore and his team understand the sources of lunar carbon. Specifically, they found that carbon from cosmic rays and solar wind is implanted into the lunar surface samples. The analyses of Apollo samples not only bolstered the reputation of the CMS as a research center, they also set the precedent for the study of all types of planetary materials by CMS researchers in the future.

CMS Collection News

New Acquisitions

The Center added an incredible variety of meteorites to the collection over the last several months, bringing the total number of meteorites in the collection to over 1620! The lastest additions are:

Batiawo - L ordinary chondrite, Burkina Faso, found ca. 2004
Carancas - H4-5 ordinary chondrite, Chucuito Province, Peru, fell September 15, 2007
Chergach - H5 ordinary chondrite, Tombouctou, Mali, fell July 2 or 3, 2007
Dar al Gani 262 - Lunar anorthosite breccia, Al Jufrah, Libya, found 1997
Dong Ujimqin Qi - Mesosiderite, Nei Mongol, China, fell September 7, 1995
Los Lunas - H4 ordinary chondrite, New Mexico, found February 1978
Northwest Africa 2932 - Mesosiderite, Northwest Africa, found 2005
Northwest Africa 3080 - L6 ordinary chondrite, Morocco, found 2003
Northwest Africa 3340 - CM2 carbonaceous chondrite, Algeria or Morocco, found 2006
Northwest Africa 5477 - L3 ordinary chondrite, Sahara, found 2008
Northwest Africa 5469 - Rumuruti-type chondrite, Northwest Africa, found 2008
Oum Dreyga - H3-5 ordinary chondrite, Rio de Oro, Western Sahara, fell October 16, 2003
Roach - LL6 ordinary chondrite, Clark County, Nevada, found January 2, 1998
Seymchan - Pallasite, Magadan District, Russia, found June 1967
Springlake - L6 ordinary chondrite, Texas, found 1980
Thuathe - H4-5 ordinary chondrite, Berea, Lesotho, fell July 21, 2002

Do-It-Yourself Meteorite Collecting

Garvie's meteorite find. Cube is 1 cm for scale.

The Center typically relies on trades, donations or purchases to grow the size of its collection. On January 18, 2009, however, CMS Collections Manager Laurence Garvie added to the the colletion in a more direct fashion - by finding a meteorite! Garvie and his daughter, both amateur photographers, were enjoying a warm winter afternoon in the desert south west of Phoenix capturing flora and fauna on film when they came upon an unusual rock. After years of desert exploration, Garvie immediately recognized the rock as unique from the typical varnished samples littering the desert floor. Pulling the rock from a deflated sand dune surface, Garvie found it to have many of the important characteristics of a meteorite: a partially-intact fusion crust and the ability to attract a magnet. Upon returning the find to the lab, Garvie found that a cut face of the 340.5 g specimen revealed chondrules, fresh metal and sulfides making it an ordinary chondrite. Outside of Center Director Meenakshi Wadhwa's participation in meteorite hunting through the joint NASA-National Science Foundation's Antarctic Search for Meteorites program, Garvie's find marks the first time a member of the Center has found a meteorite.

CMS Research News

Meteorite in the Spotlight: D'Orbigny

D'Orbigny (44.5 g). Cube is 1 cm for scale.

The meteorite D'Orbigny was found in Argentina in 1979 when a farmer hit something while plowing his normally rock-free field. Thinking it was an archaeological artifact, the farmer kept the object, but in 2000 it was discovered that his find was very rare type of meteorite called an angrite. Angrites, a small group of achondrite meteorites, are among the oldest igneous rocks in the Solar System. The Center's D'Orbigny specimen (image, right), donated by Dr. Jay Piatek in 2007, is currently under study by School of Earth and Space Exploration graduate student Greg Brennecka. Brennecka is working to better constrain the absolute formation age of D'Orbigny. This absolute age is important because it is used to determine the absolute ages of other meteorites whose ages can only otherwise be determined with relative, short-lived isotope dating techniques. Determining the absolute ages of meteorites like D'Orbigny, which are over 4.5 billion years old, requires a method called lead-lead dating. Lead-lead dating gets its name because two isotopes of lead (^{206}Pb and ^{207}Pb) are the stable decay products from the radioactive decay of two isotopes of uranium (^{238}U and ^{235}U, respectively). The long-lived decay of U to Pb allows researchers to use the Pb isotope pair to determine the ages of very old materials. For decades it has been thought that the ^{238}U/^{235}U ratio, a key parameter in calculating lead-lead dates, was constant in all natural materials. However, modern analytical techniques and mass spectrometers are now able to measure slight differences in the ^{238}U/^{235}U ratio. This implies that previously obtained ages of certain meteorites will need to be adjusted using the correct measured U isotope ratio. For some meteorites, these age adjustments are likely to be more than 1 million years. Brennecka's research focuses on understanding why variations in the ^{238}U/^{235}U ratio exist, and recalculating the ages of meteorites like D'Orbigny that help to define the age of our Solar System.

CMS Outreach News

CMS Improves Education and Outreach Efforts


The Mars-Earth Comparison module

With the support of a grant from ASU's Women and Philanthropy organization, the Center has enhanced its education and public outreach efforts through two initiatives. First, The Center completed development of two loanable teaching modules, "Mars-Earth Comparison" and "Rocks from Space: Origins of Meteorites". Both modules are filled with books, DVD's, real meteorite specimens and other teaching materials so that teachers can bring topics in planetary science to their classrooms. The modules will be available for loans in Fall 2009 and will be part of the training at the ASU Mars Education Program teacher workshop in September 2009. Second, the Center redesigned its website (http://meteorites.asu.edu) in order to improve its content and accessibility. The new site will launch in late spring 2009.

Upcoming Outreach Events!

March 27 and April 24: Astronomy Open House

ASU Tempe Campus, Bateman Physical Sciences H-wing roof, 8-10 PM. Enjoy telescope viewing, a hands-on meteorite display and more! The Open House website is at http://homepage.mac.com/agfuentes/openhouse.html

May 13: International Museum Day

ASU Tempe Campus, 9 AM - 4PM. The ASU Museums, Galleries and Collections group provides a variety of presentations and tours of ASU collections, including the CMS. Visit http://www.asu.edu/museums/ for the final schedule as the date nears.

Center Outreach in Action!

Left: CMS researchers Lev Spivak-Birndorf and Audrey Bouvier host the hands-on meteorite display at an ASU Mars Education Program teacher workshop on February 28, 2009.

Right: CMS was featured in the ASU College of Liberal Arts and Sciences Dean's display case from January to March 2009.

Center for Meteorite Studies Gift Form

The Center for Meteorite Studies plans to continue providing the public and the scientific community access to the largest university-based collection of meteorites in the world and your support will help. To contribute, please detach the following form and mail with your check or other payment information to: **ASU Foundation, PO Box 2260, Tempe, AZ 85280-2260**

Yes! I am pleased to support the Center for Meteorite Studies at Arizona State University through a gift of:
____Adopt a Meteorite ($250) ____ Friend of the Center ($100) ____Other (please specify amount)

"Adopt a Meteorite" supports the care and maintenance of the Center's meteorite collection. We will provide you with a photo and certificate of your meteorite, feature your meteorite in the museum for a period of time and provide you with an update when your sample is used by a scientist for study. In addition, you'll receive the "Friend" benefits below.

As a "Friend of the Center", you will receive benefits including our biannual newsletter, invitations to "Friends Only" lectures and tours of the collection and a Center for Meteorite Studies magnet with which you can search for your own meteorites!

Please select payment method:
Check (payable to ASU Foundation) Visa MasterCard Discover AMEX
Card Number_____ Exp. Date_____
Signature _____ Date_____
Name_____
Address_____
My (or my spouse's) employer is a matching gift company. Name of the employer _____
The full amount of your payment may be considered a charitable contribution. All funds will be deposited with the ASU Foundation, a separate non-profit organization that exists to benefit ASU. Please mail your check and this form to: **ASU Foundation, PO Box 2260, Tempe, AZ 85280-2260**
Thank you! Your generous support is appreciated! Account #30002622
